Green pitcher plant
(*Sarracenia oreophila*)

5-Year Review:
Summary and Evaluation

September 2013

Green pitcher plant
Photo by M. Scott Wiggers, USFWS

U.S. Fish and Wildlife Service
Southeast Region
Mississippi Field Office
Jackson, Mississippi

5-YEAR REVIEW
Green pitcher plant (*Sarracenia oreophila*)

I. GENERAL INFORMATION

A. Methodology used to complete the review: In conducting this 5-year review, we relied on the best available information pertaining to historical and current distributions, life history, genetics, habitats, disturbances to existing sites, and potential threats of this species. We announced initiation of this review and requested information in a published *Federal Register* notice with a 60-day comment period (75 FR 18233). In an effort to acquire the most current information available, various sources were solicited, including data housed at State natural heritage programs, internet searches, and knowledgeable individuals associated with academia, and Federal, State, and non-governmental conservation organizations. Specific sources included the final rule listing this species under the Endangered Species Act; the Recovery Plan; peer reviewed scientific publications; unpublished field observations by the U.S. Fish and Wildlife Service, U.S. Forest Service, National Park Service, State and other experienced biologists; unpublished studies and survey reports; and notes and communications from other qualified individuals. The completed draft review was sent to affected Service offices and six peer reviewers for review. Comments were evaluated and incorporated into this final document as appropriate (see Appendix A). We did not receive any public comments during the 60-day open comment period.

B. Reviewers

Lead Region: Southeast Region, Kelly Bibb, (404) 679-7132

Lead Field Office: Mississippi Field Office, M. Scott Wiggers, (601) 364-6910

Cooperating Field Offices: Daphne Ecological Services Field Office, Shannon Holbrook, (251) 441-5837; Georgia Ecological Services Field Office, Pete Pattavina, (706) 613-9493; Asheville Ecological Services Field Office, Mara Alexander, (828) 258-3939.

C. Background:

1. **Federal Register Notice citation announcing initiation of this review:** April 9, 2010. 75 FR 18233.

2. **Species status:** Stable. Currently, 15 extant green pitcher plant populations, representing 31 colonies/sites, are known across the species' range. Five of these populations (10 colonies/sites) are found on stream banks and are considered to be naturally ephemeral as the habitat is periodically disturbed (e.g., scoured) by intense flooding events. Ten green pitcher plant populations (20 colonies/sites) are protected range-wide. Three populations (4 colonies/sites) are protected by The Nature Conservancy in Alabama, Georgia, and North Carolina. The State of Alabama

protects two populations (2 colonies/sites), one of which is a streambank site that is considered to have poor estimated viability. The remaining five populations (15 colonies/sites) are protected by the National Park Service; however, the current status of three of these populations (7 streambank colonies/sites) in Alabama is unknown, but two (6 colonies/sites) are estimated to have poor viability by the Alabama Natural Heritage Program. While new colonies/populations have been discovered in Alabama and Georgia since the species was listed, others have been lost to logging activities, encroachment of competing vegetation, and cattle trampling in Alabama and North Carolina. At least one streamside colony in Alabama was lost during a flood in the 1990s.

3. **Recovery achieved:** 2 (26-50% recovery objectives achieved). Ten of 15 extant green pitcher plant populations have been protected. Four of these protected populations are streambank sites in the Little River and have little available monitoring data, although recent observations indicate that one of these sites is in decline. Earlier assessments of all but one of the remaining streambank sites by the Alabama Natural Heritage Program suggest that these sites are of poor viability. Furthermore, these streambank sites are subject to periodic flood disturbance and are considered to be naturally ephemeral. The remaining 6 protected populations are upland bogs, 5 of which are apparently stable or increasing. However, in the absence of natural fire regimes, these upland bog sites require active management to maintain and enhance their green pitcher plant populations.

4. **Listing history**
   Original Listing
   FR notice: 44 FR 54922
   Date listed: September 21, 1979
   Entity listed: species
   Classification: endangered

5. **Associated rulemakings:** None.

6. **Review History:** Recovery Plan: 1983; 1985, First Revision; 1994, Second Revision
   Recovery Data Call: Annually from 2000-2013
   Five-year review: November 6, 1991 (56 FR 56882)
   In this review, multiple species were simultaneously evaluated with no species-specific, in-depth assessment of the five factors or threats as they pertained to each species' recovery. The notice summarily listed the species and stated that no changes in the designation of these species were warranted at that time, including no changes to the status of the green pitcher plant.

7. **Species' Recovery Priority Number at start of review (48 FR 43098):** 8
   Degree of Threat: Moderate
   Recovery Potential: High
   Taxonomy: species

8. **Recovery Plan**
   Name of Plan: Green Pitcher Plant Recovery Plan
   Date Issued (Original): May 11, 1983
   First Revision: April 5, 1985
   Second Revision: December 12, 1994

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

The Endangered Species Act (ESA) defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPSs to only vertebrate species of fish and wildlife. Because the species under review is a plant, the DPS policy is not applicable.

B. Recovery Criteria

1. **Does the species have a final, approved recovery plan containing objective, measurable criteria?** Yes. However, these criteria could be made more quantifiable as more information has become available about the species.

2. **Adequacy of recovery criteria.**

   a. **Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?** Yes.

   b. **Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?** Yes.

3. **List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:**

   The stated Recovery Objective is to delist green pitcher plant. This species may be delisted when a minimum of 18 viable populations (confirmed for at least 20 years of monitoring), representing the diversity of habitats and the geographic range of the species, are protected and managed as necessary to ensure their continued existence. Colonies should also include the spectrum of current genetic variation found in the species. At least three colonies should be located within each of the following geographic areas: Coosa Valley, Lookout Mountain, Sand Mountain (East), Sand Mountain (West), and Lake Chatuge.

   These criteria have been partially met. There are currently 15 extant green pitcher plant populations, representing 31 colonies/sites in 3 states. Since listing and writing of the recovery plan, 10 populations have been permanently protected range-wide, including 9 (17 colonies/sites) in Alabama and one in Georgia and North Carolina (2 colonies/sites). These populations are found in both of green pitcher plant's primary habitats: upland bogs and streambanks. Additionally, these protected populations are

located in four of the five geographic areas required for recovery (Coosa Valley: 1; Lookout Mountain: 7; Sand Mountain-West: 1; Lake Chatuge: 1). Two additional populations (4 colonies) in Alabama (Sand Mountain-West) are temporarily protected under voluntary conservation agreements between the Service and willing landowners. However, 8 colonies (2 entire populations and portions of 3 others) have become extirpated due to cattle trampling, logging activities, and/or encroaching vegetation in Alabama (7) and North Carolina (1). Furthermore, it is unknown to what extent the protected populations represent the spectrum of genetic variation found in green pitcher plants.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. New information on the species' biology and life history:

The biology and life history of green pitcher plant has been thoroughly reviewed elsewhere (e.g., Schnell 1980; Troup and McDaniel 1980; Service 1994). Since the green pitcher plant's recovery plan was published in 1994 (Service 1994), most of the biological research on this species has focused on its associate organisms. Green pitcher plant's interactions with its pollinators have been identified as crucial to the species' conservation by D. Folkerts (1999), noting that small, isolated (remnant) green pitcher plant colonies/populations are pollinator-limited. As queen bumblebees (*Bombus* spp.) are considered to be the primary pollinator of green pitcher plants (G. Folkerts 1992; D. Folkerts 1999), anything that reduces bumblebee efficacy as pollinators, may adversely affect green pitcher plants' ability to sexually reproduce. Consequently, genetic flow between plants and nearby colonies via pollen transfer would be reduced.

As D. Folkerts (1999) exhaustively describes, pitcher plants (*S. oreophila* and relatives) also interact with a wide variety of other arthropod species, noting that these interactions have co-evolved. As such, the decline of pitcher plant populations, including the green pitcher plant, will likely be associated with declines in their insect associates. Indeed, Folkerts and Folkerts (1996) contend that observed reductions in *Exyra* moth diversity is related to extirpation of their pitcher plant hosts, such as the green pitcher plant. For example, *Exyra semicrocea* was not observed during recent visits to a variety of small, isolated green pitcher plant colonies where this moth was previously known to occur (Stephens and Folkerts 2012). Additionally, a new species of flesh fly, *Fletcherimyia oreophilae*, was recently discovered, subsequently described, and named after its only known host plant *S. oreophila* (Dahlem and Naczi 2006). As no other plant species is known to host *F. oreophilae*, the extinction of green pitcher plants could lead to the extinction of at least one other species.

Still other studies have sought to identify species that were previously not known to be associated with green pitcher plants or were poorly understood. One such study by Glenn and Bodri (2012) used genetic analyses to isolate fungal

endophytes from green pitcher plant pitchers. Four strains of endophytic fungi were identified from green pitcher plants: *Colletotrichum gloeosporioides* (2 strains), *Xylariales* sp., and *Pleosporales* sp. The authors suggest that these endophytes may produce chemical compounds (metabolites) that benefit their pitcher plant hosts, protecting them from pathogens and promoting growth. Similarly, Kuntz (2011) found that the endophytic nitrogen-fixing bacteria *Burkholderia* spp. associated with the green pitcher plant may stimulate plant overall plant growth. This beneficial relationship, however, is dependent on available nitrogen, as *Burkholderia* spp. may compete with *S. oreophila* for other nutrients when excess nitrogen is present.

Fire is an effective and important tool for managing pitcher plant bogs (44 FR 54922; Service 1994) and helps to reduce competing vegetation, such as woody species (Burton 2013, *in litt.*). Fires may also have a stimulatory effect on pitcher production of green pitcher plant, as indicated by monitoring data (Hodges 2013a, b, *in litt*.). These same data indicate that increased pitcher production comes with the cost of reduced flower production during fire years. However, this short-term cost may be outweighed by long-term increases in flower *and* pitcher production, particularly over multiple repeated cycles of prescribed fire (Hodges 2013a, *in litt.*).

b. Abundance, population trends, demographic features, or demographic trends:

Populations

Earlier documents and authors have equated green pitcher plants colonies or sites with populations (e.g., 44 FR 54922; Service 1994). This concept of population does not take into account spatially dependent ecological phenomena that are important for the conservation of this species, such as plant-pollinator interactions. In particular, pollination is of critical importance to the conservation of green pitcher plants and is spatially dependent (D. Folkerts 1999). As noted above, queen bumblebees (*Bombus* spp., particularly *B. pennsylvanicus* queens) are the primary pollinator of green pitcher plants (G. Folkerts 1992; D. Folkerts 1999). G. Folkerts (1992) further noted that flight distances of queen bumblebees are typically less than one mile (cf. Heinrich 1977). At distances greater than 1 mile, pollen flow (and consequent gene flow) is restricted by the inability of pollinators to traverse this distance. As such, for the purposes of this review, populations of the green pitcher plant are considered to be plants or colonies separated from other plants/colonies by at least one mile. This provisional population definition does not incorporate seed dispersal distance, which is poorly understood for this species. However, a study of a related, wide-spread pitcher plant species, *Sarracenia purpurea*, indicates that seed dispersal distance from parent plants is typically only a few inches (Ellison and Parker 2002). These authors further suggest that water may facilitate dispersal over longer distances for *Sarracenia* species. Indeed, flooding events are thought to be responsible for the establishment of some green pitcher plant colonies (G. Folkerts 1992). For

example, flooding may have transported seeds from upland bog colonies to suitable streambanks within the Little River watershed (Emanuel 1998).

Using this provisional population definition described above, green pitcher plant's 31 extant colonies/sites represent 15 populations, range-wide. Accordingly, both extant green pitcher plant colonies in Georgia (1) and North Carolina (1), together, represent one population. Similarly, Alabama's 28 colonies/sites represent 14 populations.

Assessment of green pitcher plant populations is complicated by the species' clonal nature and by inadequate monitoring. Green pitcher plant can spread by both sexual reproduction (via production of seeds and subsequent recruitment of seedlings) and asexual, vegetative clones (via underground rhizomes) (G. Folkerts 1992; Service 1994). Because of the clonal nature of green pitcher plant, individual populations can be thought of in terms of both genetically distinct individuals (genets) and clones (ramets). Genets are often composed of numerous ramets and, as such, population sizes in terms of ramet counts overestimate the actual population in terms of genets (Tepedino 2012). Furthermore, because identifying individual green pitcher plants (often identified as "clumps") in the field is difficult, monitoring of this species typically consists of spring pitcher and flower counts that serve as proxies for number of plants (e.g., Hodges 2013b, *in litt.*). For the purposes of this review, colony/population counts or estimates will use "clumps" and "plants" interchangeably to refer to individual green pitcher plants. In addition, intensive monitoring protocols have been proposed (e.g., Sutter and Rudd 1997), but have not been consistently applied. Similarly, various colonies/populations are monitored infrequently, monitored at inconsistent frequencies, or have not been monitored for over 15 years. This latter concern poses a particular problem for assessing most of Alabama's streambank populations in the Little River.

State Population Summaries

Alabama

Most (14) of extant green pitcher plant's extant populations are found in Alabama. Five green pitcher plant populations occur in Little River Canyon National Preserve, while DeSoto State Park is home to two populations. The Nature Conservancy (TNC) protects an additional two populations. In addition, the Service and willing landowners cooperate under voluntary conservation agreements to protect two privately-owned populations. The remaining three populations are located on private lands and have no formal protection or conservation agreements. Additionally, seven colonies (totaling over 500 clumps/plants), representing two unique populations and portions of three others, have become extirpated since the early1990s (Sutter and Rudd 1997; Emanuel 1998, 2002; Alabama Natural Heritage Program 2012; Byrd 2013a). Extensive searches in 1995 in the Coosa Valley (Cherokee and Etowah Counties) did not discover any new populations (Spaulding and

Spaulding 1995), but one small colony was recently discovered near an existing population in 2012 (Byrd 2013a).

Five of Alabama's extant green pitcher plant populations (representing 10 colonies) occur on streambanks and, as such, are considered naturally ephemeral populations and likely contribute little to the long-term survival of this species (*sensu* G. Folkerts 1992). Furthermore, only two of these populations (three colonies) have been recently observed (Byrd 2013b, *in litt.*; Wiggers 2013, pers. obs.) and have experienced declines from earlier years. Of the remaining three streambank populations, two (six colonies) were previously ranked by the Alabama Natural Heritage Program (ALNHP) (2012) as having "poor estimated viability", while the remaining population (one colony) was considered to have "good estimated viability" by ALNHP.

The National Park Service's Little River Canyon National Preserve (LRCNP or "the Preserve"), in Cherokee and DeKalb Counties, is home to more green pitcher plant colonies (15) than any other property within the species' range. Green pitcher plants within the Preserve are found in both upland bogs and streambanks along the Little River (Emanuel 1998). Together, LRCNP's eight bog colonies represent two populations and support approximately 1,800 plants (Sutter and Rudd 1997; ALNHP 2012). Two of these colonies extend onto private property adjacent to the Preserve. LRCNP staff periodically hand thin and/or burn their green pitcher plant bogs (Burton 2013, *in litt.*; Shew 2013a), although growing season burns are not possible on LRCNP (Shew 2013d, *in litt.*). Monitoring of these populations, however, occurs at irregular intervals and consists of pitcher and flower counts (Shew 2013a), but Shew (2013d, *in litt.*) notes that plants respond favorably 1 and 2 years post-burn, with hardwood encroachment becoming detrimental during the 3rd year following fire. LRCNP's streambank seven green pitcher plant colonies represent three populations. Streambank colonies along the Little River are subject to periodic disturbance from floods and, as such, have received limited management (e.g., hand thinning) (Emanuel 1998) and monitoring, with no apparent monitoring since the mid-1990s (Gunn 1996, *in litt.*; ALNHP 2012). Previous population counts/estimates of these streambank colonies note that their populations ranged from 12 to hundreds of plants (Emanuel 1998). At least one streambank colony, discovered in 1992, may have been destroyed by a flood, as the colony was not relocated in 1996 (Emanuel 1998). Management and monitoring activities on the Preserve are limited by inadequate financial and staffing resources (Shew 2013a), but National Park Service staff are pursuing additional support for LRCNP's management green pitcher plant management activities (Shew 2013d, *in litt.*). Limited monitoring of green pitcher plants on the Preserve hinders quantitative assessment of population trends on the Preserve; however, Shew (2013a) contends that these populations are generally stable on the Preserve. Additionally, Burton (2013, *in litt.*) notes that these limited monitoring data indicate apparent increases in pitcher and flower production since 1998.

DeSoto State Park, in DeKalb County, is currently home to two green pitcher plant populations representing two colonies. The smaller of the two colonies/populations is a streambank site along Little River. This colony has been in apparent decline over the past two decades, as population counts were estimated at 50 to 60 plants in 1992 and 27 clumps were counted in 2000 (ALNHP 2012). More recently (2013), only three clumps were found, but dense growth of brush and herbaceous species may have obscured any additional plants (Wiggers 2013, pers. obs.). The Park's second extant colony/population occurs within an upland bog and is apparently stable. Recent observations of this colony indicate that it consists of approximately 150 to 200 clumps (Wiggers 2013, pers. obs.), which comport with earlier (1992) estimates of 150 to 170 clumps (ALNHP 2012). A third bog colony, which was adjacent to a pasture, near the extant bog colony is no longer extant. This colony consisted of 20 to 30 plants in the early 1990s, but had declined to seven clumps in 2000 due to trampling by cattle. Poaching of four clumps later in 2000 prompted the remaining three plants to be transplanted elsewhere (Emanuel 2002; ALNHP 2012). Currently, the site is now heavily overgrown and shaded (Thomas 2013c, *in litt.*). While no formal management plan exists for the green pitcher plant colonies at DeSoto State Park, Park staff have recently begun managing the two extant colonies with prescribed fire and hand clearing (Thomas 2013b, *in litt.*; Hughes 2013, pers. comm.).

The Nature Conservancy protects and manages two populations (2 colonies) in Cherokee and DeKalb Counties. Both of these populations occur in seepage bogs and receive regular management, including hand thinning and prescribed fire. Despite regular burning and hand clearing of competing vegetation, TNC's DeKalb County population has declined from 49 clumps in 1996 to 4 clumps in 2013. Recent dry conditions may be behind this decline. In contrast, TNC's Cherokee County preserve protects a large—estimated to have over 1,000 plants—and thriving green pitcher plant population; however, plant poaching is a constant concern for this population (ALNHP 2012; Byrd 2013a).

Ten green pitcher plant colonies (five populations and part of a sixth) are privately-owned in Alabama. These colonies are found in Cherokee, DeKalb, Etowah, and Marshall Counties. Of these colonies, four (2 populations) are temporarily protected and managed under voluntary cooperative agreements between the Service and willing landowners. Together, these cooperative agreements help conserve over 1,000 plants (Sutter and Rudd 1997; ALNHP 2012; Byrd 2013a). The six remaining privately-owned green pitcher plant colonies (three populations and part of a third) have no formal protections, although some receive limited management and monitoring via cooperative efforts between willing landowners, the Service, TNC, Atlanta Botanical Garden, and Alabama Plant Conservation Alliance. Over the years, these cooperative efforts have also included the Alabama Natural Heritage Program as well as State natural resource management agencies. Two of these colonies (one population) are streambank sites along the Little River in DeKalb County

and, together, currently support at least six plants (Byrd 2013b, *in litt.*), which is a decline from 112 plants in 1985 (Sutter and Rudd 1997). Approximately six clusters of plants comprise another, recently discovered colony (considered part of a previously known population in DeKalb County) in a shallow drainage area (Byrd 2013a). The remaining three privately-owned bog colonies (two populations) are located in Marshall and Etowah Counties and once supported nearly 2,500 plants, combined, but may have declined in recent years. In addition, portions of two colonies occur on both Little River Canyon National Preserve and adjacent, privately-owned properties. Together, these two partial colonies have an estimated 12 clumps (Sutter and Rudd 1997; ALNHP 2012; Byrd 2013a).

Alabama's seven extirpated colonies are located in Cherokee, DeKalb, Etowah, Jackson, and Marshall Counties. Five of these extirpated colonies were found on privately-owned lands and were variously extirpated by cattle trampling, logging activity, and/or encroachment of competing vegetation (ALNHP 2012; Byrd 2013a). The remaining two colonies were found on DeSoto State Park and Little River Canyon National Preserve, extirpated by cattle trampling and flood scouring, respectively.

Georgia

Georgia is home to one natural green pitcher plant colony in Towns County (Dennis 1980; Service 1994; Georgia Natural Heritage Program [GANHP] 2013). This colony is owned, protected, and managed by TNC (GANHP 2013; Hodges 2013b, *in litt.*). As of 2005, this population consisted of over 1,000 green pitcher plant clumps (Hodges 2005, *in litt*.). Recent monitoring, however, does not include total clump counts, relying instead on pitcher, flower, and juvenile clump counts as indicators of population health (Hodges 2013a, *in litt.*). Overall, these data indicate that the preserve's green pitcher plant population is increasing. Searches throughout this state have not found other populations (e.g., Hillestad 1984; Jones 1985; Allison 1993).

North Carolina

North Carolina is home to one extant green pitcher plant colony in Clay County. This colony is owned, protected, and managed by TNC (Service 1994; North Carolina Natural Heritage Program [NCNHP] 2012). Green pitcher plant monitoring at this TNC preserve consists of monitoring plants within defined transects, rather than complete counts (Roe and Croll 2009). Monitoring indicates that this colony, which consists of at least several hundred clumps (NCNHP 2012), is increasing (Roe and Croll 2009). A small, neighboring colony (eight clumps) that was considered extant at the time the recovery plan was written (Service 1994) is now considered extirpated, possibly due to cattle activity (NCNHP 2012).

Tennessee

No green pitcher plant populations have been found in Tennessee since listing and the green pitcher plant is considered to be extirpated from Tennessee (Chester et al. 2009; Crabtree 2011, *in litt.*). However, the identification of the original collection from this state is questionable and cannot be confirmed (Dennis 1980; Crabtree 2011, *in litt.*).

c. Genetics, genetic variation, or trends in genetic variation:

Various genetic studies involving *Sarracenia oreophila* have attempted to elucidate the taxonomic and phylogenetic relationships of *S. oreophila* to other species of *Sarracenia* (e.g., Bayer *et al.* 1996; Neyland and Merchant 2006; Ellison *et al.* 2012). Similarly, additional studies of morphological characters and other observable traits have attempted to clarify such relationships (e.g., McDaniel 1971; Schnell and Krider 1976; Schnell 1978a, b; Schlauer *et al*. 2005; Oswald *et al.* 2011). Specific taxonomic and phylogenetic relationships within the genus *Sarracenia* regularly differ among these various treatments. Some of these differences could be due, in part, because of regular hybridization among co-occurring *Sarracenia* species (*sensu* Rogers *et al.* 2010). Of particular note from recent genetic studies are findings by Neyland and Merchant (2006) and Ellison *et al.* (2012) that *S. oreophila* is genetically similar to members of the "*S. rubra* complex" (*sensu* Mellichamp and Case 2009). However, *S. oreophila*'s status as a discrete species is not challenged because the species is morphologically distinct (Neyland and Merchant 2006). Furthermore, Neyland and Merchant (2006) and Ellison *et al.* (2012) suggest that *S. oreophila* and other closely related *Sarracenia* species evolved and radiated relatively recently, perhaps via hybridization (Ellison *et al.* 2012; Mellichamp and Case 2009) or other mechanisms.

Conservation genetic studies of *S. oreophila* are limited. Godt and Hamrick (1996) studied genetic diversity and structure of *S. oreophila* and its relative *S. jonesii* (synonymous with *S. rubra* ssp. *jonesii* and also federally endangered) using allozymes. Both of these species were found to have low genetic diversity and, furthermore, that genetic diversity declined with decreasing population sizes. Within *S. oreophila* populations, those occurring in Alabama were found to be genetically distinct from those in Georgia and North Carolina. Godt and Hamrick (1996) suggested that isolation of these state populations, via loss of intermediate *S. oreophila* populations, likely limited gene flow (e.g., pollen and seed dispersal) between them, and thus contributed to their genetic distinctiveness. Godt and Hamrick (1996) found no genetic differences between *S. oreophila* habitats sampled (streambanks and flatwoods bogs). Additionally, Godt and Hamrick (1999) noted that both *S. oreophila* and *S. jonesii* are less genetically diverse than their more widespread congeners *S. purpurea* and *S. rubra*. Interestingly, *S. oreophila* and *S. jonesii* are also less genetically diverse than their rare relative (and federally endangered) *S. rubra* ssp. *alabamensis*, which is endemic to Alabama (Godt and Hamrick 1998). Similarly, Furches *et al*. (2013) found that *S. oreophila* is less genetically diverse than its more widespread relatives *S. alata*, *S. leucophylla*, and *S. rubra* ssp. *wherryi*. The authors also noted strong differentiation between Alabama and Georgia/North Carolina populations and

found the greatest genetic diversity in populations sampled in the Little River canyon area. In order to assist future conservation genetic and evolutionary studies of *Sarracenia* species, Rogers *et al.* (2010) have also identified a suite of microsatellite markers in *S. oreophila* and other *Sarracenia* species.

d. Taxonomic classification or changes in nomenclature:

The taxonomy of *Sarracenia oreophila* was reviewed by the Service for recovery plan (Service 1994), and is currently recognized as an accepted taxon by the Integrated Taxonomic Information System (2013) and *Flora of North America* (Mellichamp and Case 2009).

e. Spatial distribution, trends in spatial distribution, or historic range:

Green pitcher plant is currently found in Alabama, Georgia, and North Carolina. The species is also thought to have once occurred in Tennessee; however, the identification of the original collection from this state is questionable and cannot be confirmed (Dennis 1980; Crabtree 2011, *in litt.*). Accordingly, the species is no longer considered to be part of Tennessee's flora (Chester *et al.* 2009; Crabtree 2011, *in litt.*). Within green pitcher plant's extant range, the species' distribution can be broadly divided into four geographic areas: Coosa Valley, Lake Chatuge, Lookout Mountain, and Sand Mountain (Service 1994). Lake Chatuge green pitcher plant colonies are restricted to Georgia and North Carolina, whereas Coosa Valley, Lookout Mountain, and Sand Mountain green pitcher plant distribution is restricted to Alabama.

f. Habitat:

The green pitcher plant is classified as an obligate wetland species (Lichvar 2012), meaning that the species almost always occurs in wetlands (Lichvar *et al.* 2012). Green pitcher plant habitats can be generally grouped into two types: streambanks and upland bogs (Troup and McDaniel 1980; Service 1994; Sutter and Rudd 1997). Streambank colonies are considered to be ephemeral, even though they may last for decades, because flooding events can wash these sandy-soiled sites (and the green pitcher plants) away (G. Folkerts 1992; Emanuel 1998). Indeed, at least one streambank population in the Little River watershed is thought to have been washed away by a large flood event in the early 1990s (Gunn 1994, *in litt.*, 1996, *in litt.*; Emanuel 1998). However, these periodic scouring floods may also remove competing vegetation from streambank sites (NatureServe 2013). Upland bogs require periodic fires to control competing vegetation and maintain relatively open conditions. These sites occur in a range of open to forested conditions and are thought to be underlain by semi-impervious clay layers that help maintain the relatively moist soil conditions needed by green pitcher plants (Schnell 1980; Troup and McDaniel 1980; Service 1994; Sutter and Rudd 1997). As D. Folkerts (1999) notes, plant communities with pitcher plants often are generically referred to as "pitcher plant bogs," regardless of other important factors, such as abundance of other species. Recent studies in Alabama

and North Carolina have sought to further refine and describe these green pitcher plant "bogs".

Carter *et al.* (2006) studied bogs in Little River Canyon National Preserve (Alabama) and identified green pitcher plants as occurring in three main community types: *Nyssa sylvatica-Liriodendron tulipifera-Rhododendron canescens* (NLR), *Quercus coccinea-Cornus florida-Solidago speciosa* (QCS), and *Aureolaria flava-Lobelia spicata-Lespedeza violacea* (ALL). Both NLR and QCS types were associated with small streams, whereas ALL type sites were not associated with streams. Streams associated with the NLR type were ephemeral, whereas QCS type streams were perennial. Furthermore, these authors identified a variety of co-occurring plant species shared among all community types, including the common species *Acer rubrum*, *Pinus taeda*, *Smilax rotundifolia*, and *S. glauca*. The geographic scope of Carter *et al.* (2006) was expanded beyond Little River Canyon National Preserve by Boyer and Carter (2011). Similar to the earlier study, Boyer and Carter (2011) identified three plant community types associated with green pitcher plants: *Quercus rubra-Arundinaria appalachiana-Pinus echinata* (QAP), *Quercus falcate-Diospyros virginiana-Rhododendron canescens* (QDR), and *Rhexia virginica-Dichanthelium scoparium-Carex glaucescens* (RDC). The authors described the QAP type as being composed mostly of upland plant species, but noted that green pitcher plants probably occurred in a zone of moist soil in an otherwise dry area. Similarly, the authors suggest that small, ephemeral streams maintain conditions moist enough to support green pitcher plants in the QDR type. Finally, the authors describe the relatively open RDC type as seepage springs that support a variety wetland species.

Other studies provide additional insight into North Carolina and Georgia habitats. Weakley and Schafale (1994) describe green pitcher plants in these sites as occurring in low mountain seepage bogs, noting that these habitats have a wide variety of plant species in common with fire-maintained Coastal Plain communities. The authors further note that this wetland type is only found in Clay County, North Carolina and Towns County, Georgia. Boyle *et al.* (2011) further describes this habitat as a type of sphagnum and shrub bog and seep, specifically as an *Alnus serrulata-Rhododendron arborescens/Sarracenia oreophila-Rhynchospora rariflora* shrubland. Unlike the previous authors, Wilcox (2012) contends that the North Carolina site is more accurately referred to as a fen, rather than a bog, because the hydrology is driven by groundwater rather than precipitation.

g. Other:

Propagation and Safeguarding

A variety of organizations have established collections of green pitcher plants to assist the long-term survival and conservation of this species. For example, Atlanta Botanical Garden maintains a safeguarding collection of live plants

representing more than 20 colonies across green pitcher plant's extant range (Determann 2013a, *in litt.*). In addition, the North Carolina Botanical Garden (NCBG) serves as the Center for Plant Conservation's (CPC) primary custodian for green pitcher plant (CPC 2010). Accordingly, NCBG is cooperating with the National Center for Genetic Resource Preservation (NCGRP) to maintain seed collections from sites across the species' range in long-term frozen storage (Kunz 2013, *in litt.*; Randall 2013, *in litt.*; Walters 2013a, *in litt.*). These collections, however, are limited and additional seed collections of unrepresented or underrepresented colonies/populations are warranted (cf. Service 1994; CPC 2010). Preliminary data from NCGRP's collections suggest that *Sarracenia* seeds may best be stored in liquid nitrogen (Walters 2013b, *in litt.*). Specific protocols for cryogenic storage of *S. oreophila* and related species have recently been developed (Northcutt *et al.* 2012). Furthermore, propagation protocols, using both conventional and non-conventional methods, have been developed for a variety of *Sarracenia* species, including *S. oreophila* (Thomas 2002; Northcutt *et al.* 2012).

Transplanting and Population Establishment

Since listing, transplanting green pitcher plants to establish and augment populations has been attempted, but most of these transplant experiments have not been effective (Service 1994). As described in the recovery plan (Service 1994), the U.S. Forest Service outplanted green pitcher plants at two sites on National Forest lands in Georgia during the late 1980s and early 1990s. Today, despite regular management by prescribed fire, only one of these sites still exists (Baggs 2013, *in litt.*). Baggs (2013, *in litt.*) suggested that the failed Forest Service transplant site may have simply been unsuitable for this species.

Educational Outreach

Within the southeastern United States, a variety of private and public conservation institutions are working to educate the public about the green pitcher plant. For example, staff members at DeSoto State Park have worked with a local Eagle Scout candidate (Boy Scouts of America) and with Atlanta Botanical Garden staff to establish a green pitcher plant educational display at the Park (Thomas 2013a, *in litt.*). Similarly, Jacksonville State University and Little River Canyon National Preserve have also sought to educate the public about green pitcher plants via educational displays and programs (Shew 2013b, *in litt.*).

2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

a. Present or threatened destruction, modification or curtailment of its habitat or range:

Habitat destruction threatens carnivorous plant species worldwide (Schnell 2002; McPherson 2007; Jennings and Rhor 2011). Habitat destruction is of particular importance to *Sarracenia* species of the southeastern United States (Groves

1993), and, specifically, to green pitcher plants (44 FR 54922; Service 1994). The threat of habitat loss and destruction for green pitcher plants has been reduced since listing, as four populations have been permanently protected in Alabama (2), Georgia (1), and North Carolina (1) by The Nature Conservancy. Additionally, seven other populations are found on State-owned (2) and Federally-owned lands (5) in Alabama and, thus, receive protection from out-right habitat destruction. The remaining five green pitcher plant populations occur on privately-owned lands. Some (4 colonies/2 populations) of these privately-owned populations are temporarily protected from habitat destruction through voluntary conservation agreements between the landowner and the Service. Others (4) are cooperatively managed by landowners and The Nature Conservancy. However, these protections end when the conservation agreements and cooperative arrangements are no longer in effect, such as when the land is sold or landowners decide to no longer conserve the green pitcher plants on their property. The remaining six privately-owned colonies receive no formal protection from habitat destruction. Habitats of six colonies (Alabama: 5; North Carolina: 1) were degraded and destroyed by cattle trampling, logging activity, fire exclusion, and/or encroachment of competing vegetation.

Many populations of green pitcher plant exist in small, isolated populations (G. Folkerts 1992; Service 1994). These populations are genetically isolated from one another by the inability of green pitcher plant pollinators to traverse long distances (G. Folkerts 1992; D. Folkerts 1999). Development and habitat destruction are projected to continue for years to come in the southeastern United States (Stein *et al.* 2010), particularly in watersheds with green pitcher plant populations. Such development activities threaten both extant, privately-owned green pitcher plant colonies/populations; increase fragmentation and isolation of these populations; and, limit natural expansion of this species to new sites. Moreover, D. Folkerts (1999) noted that sexual reproduction of small, isolated green pitcher plant populations may also be pollinator-limited. Bumblebee movement may be hindered by roads, as has been documented elsewhere (e.g., Bhattacharya *et al.* 2003). Thus, increased road construction and expansion associated with increased development may further exacerbate pollinator-limitation for some green pitcher plant populations.

b. Overutilization for commercial, recreational, scientific, or educational purposes: Over-collection was cited as a reason for listing the green pitcher plant in 1979 (44 FR 54922) and was considered a serious threat when the current recovery plan was revised 15 years later (Service 1994). Recent reviews of threats to carnivorous species note that over-collection of wild plants and plant parts remain a persistent threat to *Sarracenia* species (McPherson 2007; Jennings and Rohr 2011). More recently, over-collection pressure from plant poachers may have declined as evidence (e.g., holes in the ground) of removal of whole green pitcher plants is limited, but not absent (Emanuel 2002; ALNHP 2012; Byrd 2013a; Determann 2013b, *in litt.*; Hermann 2013, *in litt.*; Hodges 2013c, *in litt.*; Shew 2013c, *in litt.*). Collection pressure may have been somewhat ameliorated by limited, legal interstate sale of commercially grown green pitcher plants from

U.S. Fish and Wildlife Service issued Section 10 permitted growers and sellers. However, Hermann (2013, *in litt.*) proposed that poaching of individual green pitcher plants may not be readily apparent as evidence of poaching could be easily obscured. Alternatively, Hodges (2013b, *in litt.*) suggested that poaching of plants may have shifted to unauthorized seed collection. Byrd (2013a) stated that several green pitcher plant populations are easily accessible and, thus, are vulnerable to illegal collection by poachers. Indeed, Byrd (2013a) noted that plants from at least one of these populations were recently poached.

c. Disease or predation: Disease and predation are not known to threaten this species.

d. Inadequacy of existing regulatory mechanisms: Green pitcher plant receives some legal protection in Georgia and North Carolina; however, these laws do not protect against habitat destruction. Collection of green pitcher plants on public lands without a permit is prohibited in Georgia under the Georgia Wildflower Preservation Act of 1973. No such provisions are afforded to plants found on privately-owned lands in the State. North Carolina General Statute 106-202.12-202.19, also known as the Plant Protection and Conservation Act, authorizes the State to establish a list of protected plants and regulate the collection, sale, and transport of plants on this list. Green pitcher plant is included on the North Carolina's list of protected plants. The species does not receive any specific legal protections from State laws or regulations in Alabama.

e. Other natural or manmade factors affecting its continued existence:

Genetics

As summarized by Godt and Hamrick (1996), small population sizes have been associated with low genetic diversity and reduced fitness in a variety of plant species. Within populations of *S. oreophila*, genetic diversity is relatively low and related to population size and geographic isolation. Specifically, small and isolated populations exhibit less genetic diversity than larger, less isolated populations (Godt and Hamrick 1996). Effects of small population size and low genetic diversity on *S. oreophila*'s fitness have yet to be assessed. However, together, low genetic diversity, small population sizes, and isolation of some populations may limit *S. oreophila*'s ability to respond and adapt to stochastic environmental events and future climate change.

Climate Change

The precise magnitude and impacts of climate change on the southeastern United States are uncertain, but models have projected that climate change in the region may include increased temperatures of 2 to 4°C (3.6 to 7.2°F) accompanied by reduced average annual precipitation by the end of the century (Joyce *et al.* 2011). Climate change has the potential to affect distribution and abundance of plants by influencing seasonal weather patterns, frequency and timing of severe weather

events, and myriad plant physiological responses (Hawkins *et al*. 2008). The specific impacts of climate change on green pitcher plant populations are poorly understood; however, a variety of impacts are possible. For example, climate change may threaten green pitcher plant populations if the habitats that the species relies on become drier as a result of higher temperatures and reduced rain (Devall and Parresol 1998; Wilcox 2012). Indeed, Wilcox (2012) notes that pitcher plant declines at a TNC preserve in North Carolina were associated with two droughts and lower water tables during the early 2000s. However, Davenport (2007) suggests that climate change's effects might be somewhat ameliorated for this species if drier climates increase the frequency of fires that maintain green pitcher plant habitats. In addition, climate change may disrupt plant-pollinator interactions via phenological shifts in flowering and/or pollinator activity (Memmott *et al.* 2007; Hawkins *et al*. 2008), which may thereby reduce sexual reproduction of green pitcher plants. Any disruption in pollinator efficacy may further threaten isolated green pitcher plant populations that are already pollinator limited (*sensu* D. Folkerts 1999). While disease is not currently known to threaten green pitcher plants, climate change has the potential to promote the spread of infectious diseases among plants, particularly if arthropod vectors become more widespread and abundant (Anderson *et al*. 2004; Garrett *et al*. 2006; Hawkins *et al*. 2008). Given the variety and complexity of the potential effects of climate change on plant species and communities (cf. Hawkins *et al*. 2008; Walther 2010), more research is needed to assess its potential long-term impacts on green pitcher plant populations and habitats.

Cattle and Domestic Animal Disturbance

Trampling and soil disturbance from cattle have destroyed or degraded several green pitcher plant habitats and populations (Service 1994; Gunn 1994, *in litt.*, 1996, *in litt.*; Emanuel 2002; NCNHP 2012).

Inappropriate Fire Regime

Fire is an integral part of maintaining green pitcher plant bog habitats (Service 1994; Boyer and Carter 2011; NatureServe 2013). In the absence of regular fires, competing plant species encroach on green pitcher plant habitats and out-compete the pitcher plants for resources (e.g., nutrients and light) (Troup and McDaniel 1980; Jennings and Rohr 2011). Encroachment of competing vegetation can lead to the eventual elimination of green pitcher plants (44 FR 54922). Furthermore, excessive fuel accumulation may occur at sites where fire has been excluded or occurs rarely, thus increasing the risk of re-introduced fires having potentially detrimental effects to green pitcher plants (Hermann 2014, *in litt*.). Alternatively, burning too frequently (e.g., multiple annual fires) or regularly burning during unfavorable seasons (e.g., winter) may reduce habitat suitability for green pitcher plants (Service 1994). Similarly, frequent application of early growing season burns may eliminate seedling recruitment (Determann 2013c, *in litt*.).

Development

As noted previously, development may threaten green pitcher plants on privately owned properties and limit future expansion of the species by destroying suitable habitat. Additionally, Hodges (2013d, *in litt*.) noted that development of upslope properties adjacent to the Lake Chatuge green pitcher plant preserves may disrupt the hydrology of these sites and increase pollution; thereby degrading the habitat and threatening the continued existence of these otherwise protected colonies.

D. Synthesis

When listed as endangered in 1979, the only extant natural populations of green pitcher plant were known from Alabama and the species was thought to be extirpated from Georgia and Tennessee. Since listing, the green pitcher plant was discovered in both Georgia and North Carolina, but has not been relocated in Tennessee. Additional colonies have also been found in Alabama. When the green pitcher plant's recovery plan was revised in 1994, the species was known to occur in 35 extant natural colonies/sites in Alabama, Georgia, and North Carolina. New colonies in Alabama have been found since then, but others in Alabama and North Carolina have also recently become extirpated, some within only a handful of years following their discovery. Today, 31 natural green pitcher plant colonies occur in Alabama, Georgia, and North Carolina. Using a provisional population definition of plants/colonies separated by at least 1 mile, these extant colonies represent 15 populations. Most of these colonies (28) and populations (14) are found in Alabama, with the remaining colonies occurring in Georgia (1) and North Carolina (1), which together represent one population.

Five green pitcher plant populations (10 colonies/sites) occur on streambanks of the Little River in Alabama and are considered to be naturally ephemeral, as the habitat is subject to periodic intense flooding events. Recent visits to three of these colonies (2 populations) indicate that green pitcher plants at these sites are declining. Additionally, the Alabama Natural Heritage Program previously estimated that all but one of the remaining streamside colonies have poor viability.

Overall, the threat of habitat destruction to green pitcher plants has been reduced since listing, as 10 populations (20 colonies/sites) are currently protected by The Nature Conservancy (3) in Alabama, Georgia, and North Carolina; the State of Alabama at DeSoto State Park (2); and the National Park Service at Little River Canyon National Preserve (5) in Alabama. Despite this protection, 1 colony (part of 1 population) at DeSoto State Park and 1 streambank colony (1 population) at Little River Canyon National Preserve have been lost. Furthermore, 4 of these populations are composed of naturally ephemeral streambank colonies (8) and likely contribute little to the long-term recovery of the green pitcher plant. However, green pitcher plants at all but one protected upland bog population are generally stable or increasing in size.

In the absence of natural fire regimes, conservation of upland bog green pitcher plant colonies requires active management with prescribed fire and hand thinning to reduce encroachment of competing vegetation. Furthermore, conservation of green pitcher plants on private lands is critically dependent on the support of willing landowners. Accordingly, the Service has had some success working with such willing landowners

conserving green pitcher plants on these private lands. Assistance from State and non-profit conservation organizations has also aided this work. However, these efforts are temporary and green pitcher plant colonies have declined and/or become extirpated when landowners are no longer willing or able to conserve this species on their property. Privately-owned green pitcher plant colonies represent 5 entire populations (7 colonies) and part of two otherwise protected populations (1 colony entirely privately-owned and parts of 2 other colonies are privately-owned).

While progress toward recovery has been made, primarily in the areas of population protection and habitat management, the species continues to meet the definition of endangered under the Endangered Species Act. Green pitcher plants continue to be threatened by habitat loss and degradation, primarily on private properties. The species also continues to require active management to maintain habitat quality, as fire exclusion and associated encroachment of competing vegetation can lead to declines and eventual extirpation of green pitcher plant populations. Range-wide, this species has a fragmented distribution with populations composed of small, isolated colonies that likely have limited gene flow between them. Development, forestry, and agriculture (primarily cattle activity) continue to threaten green pitcher plant populations. Collection continues to threaten this species, although its intensity has likely waned in recent years.

III. RESULTS

A. Recommended Classification:

__X__ No change is needed

B. New Recovery Priority Number: No change.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- Work with federal and state entities, non-governmental organizations, and private individuals to permanently protect and manage existing habitats and populations, including the development and implementation of management plans, as needed.
- Continue use of prescribed fires at protected sites and encourage owners of unprotected sites to conduct prescribed fires as frequently as possible.
- Study and evaluate efficacy of a variety of prescribed fire regimes.
- Study and evaluate efficacy of alternative management strategies to prescribed fire, such as hand clearing, mowing, and limited herbicide application.
- Update population inventories, create detailed maps of all populations and their habitats to assist with population management, and attempt to relocate populations.
- Characterize genetic diversity and representation of current *ex situ* safeguarded collections. Expand *ex situ* preservation of genetic stock, including long-term cryopreservation of seeds as well as live collections, to represent all populations with increased emphasis placed on preserving and safeguarding individual genets within and across populations.
- Continue and expand conservation genetics work to include all populations and determine effective population sizes.

V. REFERENCES

Alabama Natural Heritage Program (ALNHP). 2012. Alabama Natural Heritage Program database. Accessed August 3, 2012.

Allison, J.R. 1993. Searches for *Sarracenia oreophila* in northern Georgia during 1991. Unpublished report to U.S. Fish and Wildlife Service, Jackson, MS. 6 pp. + appendix.

Anderson, P.K., A.A. Cunningham, N.G. Patel, F.J. Morales, P.R. Epstein, and P. Daszak. 2004. Emerging infectious diseases of plants: pathogen pollution, climate change and agrotechnology drivers. Trends in Ecology and Evolution 19:535-544.

Baggs, J.E. 2013. Forest Botanist/Ecologist, Chattahoochee-Oconee National Forest, U.S. Forest Service. E-mail to M.S. Wiggers re: Outplanting of green pitcher plants on National Forests in Georgia. August 13, 2013.

Bayer, R.J., L. Hufford, and D.E. Soltis. 1996. Phylogenetic relationships in Sarraceniaceae based on rbcL and ITS sequences. Systematic Botany 21:121-134.

Bhattacharya, M., R.B. Primack, and J. Gerwein. 2003. Are roads and railroads barriers to bumblebee movement in a temperate suburban conservation area? Biological Conservation 109:37-45.

Boyer, T., and R. Carter. 2011. Community analysis of green pitcher plant (*Sarracenia oreophila*) bogs in Alabama. Castanea 76:364-376.

Boyle, M.F., R.K. Peet, T.R. Wentworth, M.P. Schafale, and M. Lee. 2011. Natural vegetation of the Carolinas: classification and description of plant communities of the far western mountains of North Carolina. Version 1. April, 2011. Report for the Ecosystem Enhancement Program, North Carolina Department of Environment and Natural Resources. 20 pp. + appendices.

Burton, J.A. 2013. Ecologist, National Park Service. E-mail to M.S. Wiggers re: Poster abstract submitted to Wildland Fire in the Appalachians: Discussions among Managers and Scientists meeting. Attachment. August 28, 2013.

Byrd, C. 2013a. Monitoring report for *Sarracenia oreophila*. The green pitcher plant. Unpublished report to the U.S. Fish and Wildlife Service, Jackson, MS. 33 pp.

Byrd, C. 2013b. Land Steward, The Nature Conservancy, Alabama. E-mail to M.S. Wiggers and R. Determann re: status of two green pitcher plant colonies. September 6, 2013.

Carter, R., T. Boyer, H. McCoy, and A. Londo. 2006. Classification of green pitcher plant (*Sarracenia oreophila* (Kearney) Wherry) communities in the Little River Canyon National Preserve, Alabama. Natural Areas Journal 26:84-93.

Center for Plant Conservation (CPC). 2010. CPC National Collection Plant Profile. *Sarracenia oreophila*. Website. Available at: http://www.centerforplantconservation.org/collection/cpc_viewprofile.asp?CPCNum=3821. Accessed August 20, 2013.

Chester, E.W., B.E. Wofford, D. Estes, and C. Bailey. 2009. A fifth checklist of Tennessee vascular plants. Sida Botanical Miscellany No. 31. Botanical Research Institute of Texas, Fort Worth, Texas. 102 pp.

Crabtree, T. 2011. State Botanist, Tennessee Natural Heritage Program. E-mail to M.S. Wiggers re: Occurrence of *Sarracenia oreophila* in Tennessee. August 16, 2011.

Dahlem, G.A., and R.F.C. Naczi. 2006. Flesh flies (Diptera: Sarcophagidae) associated with North American pitcher plants (Sarraceniaceae), with descriptions of three new species. Annals of the Entomological Society of America 99:218-140.

Davenport, L.J. 2007. Climate change and its potential effects on Alabama's plant life. Department of Biological and Environmental Sciences, Samford University, Birmingham, AL. 75 pp. Available at: http://www.forestry.alabama.gov/Carbon/Davenport_CLIMATECHANGE2007%20&%20Impact%20to%20AL%20Plants.pdf.

Dennis, W.M. 1980. *Sarracenia oreophila* (Kearny) Wherry in the Blue Ridge Province of northeastern Georgia. Castanea 45:101-103.

Determann, R. 2013a. Conservatory and Conservation Director, Atlanta Botanical Garden, Georgia. E-mail to M.S. Wiggers re: *Sarracenia alabamensis* and *S. oreophila ex situ* conservation at Atlanta Botanical Garden. Attachments. July 31, 2013.

Determann, R. 2013b. Conservatory and Conservation Director, Atlanta Botanical Garden, Georgia. E-mail to M.S. Wiggers re: Green pitcher plant poaching threats. August 15, 2013.

Determann, R. 2013c. Conservatory and Conservation Director, Atlanta Botanical Garden, Georgia. E-mail to M.S. Wiggers re: Comments on green pitcher plant 5-year review draft. October 31, 2013.

Devall, M.S., and B.R. Parresol. 1998. Effects of global climate change on biodiversity in forests of the southern United States. In: Mickler, R.A., and S. Fox, eds. The productivity and sustainability of southern forest ecosystems in a changing environment. Springer-Verlag, New York, pp. 663-682.

Ellison, A.M., E.D. Butler, E.J. Hicks, R.F.C. Naczi, P.J. Calie, C.D. Bell, and C.C. Davis. 2012. Phylogeny and biogeography of the carnivorous plant family Sarraceniaceae. PLoS ONE 7:e39291. doi:10.1371/journal.pone.0039291.

Ellison, A.M., and J.N. Parker. 2002. Seed dispersal and seedling establishment of *Sarracenia purpurea* (Sarraceniaceae). American Journal of Botany 89:1024-1026.

Emanuel, C.M. 1998. Vegetation management plan for *Sarracenia oreophila*, green pitcher plant. Prepared for Little River Canyon National Preserve, Ft. Payne, AL. 57 pp. + appendices.

Emanuel, C.M. 2002. Restoration management of the green pitcher plant, *Sarracenia oreophila* (Kearney) Wherry, in Alabama. Unpublished report for U.S. Fish and Wildlife Service, Jackson, MS. 60 pp. + appendix.

Folkerts. D. 1999. Pitcher plant wetlands of the southeastern United States. Arthropod associates. In: D.P. Batzer, R.B. Rader, and S.A. Wissinger, eds. Invertebrates in freshwater wetlands of North America: ecology and management. John Wiley and Sons, New York, pp. 247-275.

Folkerts, D.R., and G.W. Folkerts. 1996. Aids for the field identification of pitcher plant moths of the genus *Exyra* (Lepidoptera: Noctuidae). Entomological News 107:129-136.

Folkerts, G.W. 1992. Identification and measurement of damage caused by flower and seed predators associated with *Sarracenia oreophila* and recommended management/control measures deemed appropriate. Unpublished report to U.S. Fish and Wildlife Service, Jackson, MS. 52 pp.

Furches, M.S., R.L. Small, and A. Furches. 2013. Genetic diversity in three endangered pitcher plant species (*Sarracenia*; Sarraceniaceae) is lower than widespread congeners. American Journal of Botany 100:2092-2101.

Garrett, K.A. S.P. Dendy, E.E. Frank, M.N. Rouse, and S.E. Travers. 2006. Climate change effects on plant disease: genomes to ecosystems. Annual Review of Phytopathology 44:489-509.

Georgia Natural Heritage Program. 2013. Georgia Natural Heritage Program database. Accessed April 30, 2013.

Glenn, A., and M.S. Bodri. 2012. Fungal endophyte diversity in *Sarracenia*. PLoS ONE 7:e32980. Doi:10.1371/journal.pone.0032980.

Godt, M.J.W., and J.L. Hamrick. 1996. Genetic structure of two endangered pitcher plants, *Sarracenia jonesii* and *Sarracenia oreophila* (Sarraceniaceae). American Journal of Botany 83:1016-1023.

Godt, M.J.W., and J.L. Hamrick. 1998. Allozyme diversity in the endangered pitcher plant *Sarracenia rubra* ssp. *alabamensis* (Sarraceniaceae) and its close relative *S. rubra* ssp. *rubra*. American Journal of Botany 85:802-810.

Godt, M.J.W., and J.L. Hamrick. 1999. Genetic divergence among infraspecific taxa of *Sarracenia purpurea*. Systematic Botany 23:427-438.

Groves, M. 1993. Conservation, horticulture and trade in the genus *Sarracenia*. In: M. Groves, M. Read, and B.A. Thomas, eds. Species endangered by trade - a role for horticulture? Fauna and Flora Preservation Society, London, UK, pp. 22-27.

Gunn, S.C. 1994. Coordinator/Botanist, Alabama Natural Heritage Program. Letter to C. Norquist re: Green pitcher plant site management plans. Attachments. June 18, 1994.

Gunn, S.C. 1996. Botanist. Letter to C. Norquist re: status of green pitcher plant sites in Alabama. Attachments. June 11, 1996.

Hawkins, B., S. Sharrock, and K. Havens. 2008. Plants and climate change: which future? Botanic Gardens Conservation International, Richmond, UK. 96 pp.

Heinrich, B. 1977. The physiology of exercise in the bumblebee. American Scientist 65:455-465.

Hermann, S.M. 2013. Assistant Research Professor, Auburn University, Alabama. E-mail to M.S. Wiggers re: Green pitcher plant poaching threats. August 22, 2013.

Hermann, S.M. 2014. Assistant Research Professor, Auburn University, Alabama. E-mail to M.S. Wiggers re: Comments on green pitcher plant 5-year review draft. January 23, 2014.

Hillestad, H.O. 1984. Survey for extant populations of *Sarracenia oreophila* in the Blue Ridge Province. Unpublished report for State of Georgia, Department of Natural Resources. Atlanta, GA. 5 pp.

Hodges, M. 2005. Conservation Ecologist, The Nature Conservancy, Georgia. E-mail to C. Norquist re: Green pitcher plant status update. August 15, 2005.

Hodges, M. 2013a. Director of Stewardship, The Nature Conservancy, Georgia. E-mail to M.S. Wiggers re: Monitoring of *Sarracenia oreophila*. Attachments. July 29, 2013.

Hodges, M. 2013b. Director of Stewardship, The Nature Conservancy, Georgia. E-mail to M.S. Wiggers re: Fire effects and monitoring of *Sarracenia oreophila*. July 29, 2013.

Hodges, M. 2013c. Director of Stewardship, The Nature Conservancy, Georgia. E-mail to M.S. Wiggers re: Green pitcher plant poaching threats. August 15, 2013.

Hodges, M. 2013d. Director of Stewardship, The Nature Conservancy, Georgia. E-mail to M.S. Wiggers re: Comments on green pitcher plant 5-year review draft. September 23, 2013.

Hughes, B. 2013. Naturalist, DeSoto State Park, Alabama. Discussions with M.S. Wiggers re: Green pitcher plant management at DeSoto State Park, Alabama. June 19-20, 2013.

Integrated Taxonomic Information System. 2013. Integrated Taxonomic Information System (ITIS) [on-line database]. Available at http://www.itis.gov. Accessed July 24, 2013.

Jennings, D.E., and J.R. Rohr. 2011. A review of the conservation threats to carnivorous plants. Biological Conservation 144:1356-1363.

Jones, S.B., and N.C. Coile. 1985. Protected plant survey in Game Management Section Region I. Unpublished report for the Georgia Statewide Endangered Species Program. GA. 3 pp.

Joyce, L.A., D.T. Price, D.W. McKenney, R.M. Siltanen, P. Papadopol, K. Lawrence, and D.P. Coulson. 2011. High resolution interpolation of climate scenarios for the coterminous USA and Alaska derived from general circulation model simulations. Gen. Tech. Rep. RMRS-GTR-263, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO. 87 pp.

Kunz, M. 2013. Conservation Ecologist, North Carolina Botanical Garden, University of North Carolina at Chapel Hill. E-mail to M.S. Wiggers re: Green pitcher plant conservation at North Carolina Botanical Garden. August 21, 2013.

Kuntz, V.L. 2011. The relationship between *Sarracenia oreophila* and an endophytic *Burkholderia*. M.Sc. Thesis. Georgia Institute of Technology, Atlanta, GA. 53 pp.

Lichvar, R.W. 2012. The National Wetland Plant List. ERDC/CRREL TR-12-11. U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, NH. 9 pp. + appendices.

Lichvar, R.W., N.C. Melvin, M.L. Butterwick, and W.N. Kirchner. 2012. National Wetland Plant List indicator rating definitions. ERDC/CRREL TN-12-1. U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, NH. 7 pp.

McDaniel, S. 1971. The genus *Sarracenia* (Sarraceniaceae). Bulletin of Tall Timbers Research Station 9:1-36.

McPherson, S. 2007. Pitcher plants of the Americas. McDonald and Woodward, Blacksburg, VA. 320 pp.

Mellichamp, T.L., and F.W. Case. 2009. *Sarracenia*. In: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 16+ vols. Oxford University Press: New York and Oxford. Vol. 8, pp. 350-363.

Memmott, J., P.G. Craze, N.M. Waser, and M.V. Price. 2007. Global warming and the disruption of plant-pollinator interactions. Ecology Letters 10:710-717.

NatureServe. 2013. NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, VA. Available http://www.natureserve.org/explorer. Accessed July 24, 2013.

Neyland, R., and M. Merchant. 2006. Systematic relationships of Sarraceniaceae inferred from nuclear ribosomal DNA sequences. Madroño 53:223-232.

North Carolina Natural Heritage Program (NCNHP). 2012. North Carolina Natural Heritage Program database. Accessed July 24, 2012.

Northcutt, C., D. Davies, R. Gagliardo, K. Bucalo, R.O. Determann, J.M. Cruse-Sanders, G.S. Pullman. 2012. Germination *in vitro*, micropropagation, and cryogenic storage for three rare pitcher plants: *Sarracenia oreophila* (Kearney) Wherry (Federally Endangered), *S. leucophylla* Raf., and *S. purpurea* ssp. *venosa* (Raf.) Wherry. HortScience 47:74-80.

Oswald, W.W., E.D. Doughty, G. Ne'eman, R. Ne'eman, and A.M. Ellison. 2011. Pollen morphology and its relationship to taxonomy of the genus *Sarracenia* (Sarraceniaceae). Rhodora 113:235-251.

Randall, J.L. 2013. Director of Conservation Programs, North Carolina Botanical Garden, University of North Carolina at Chapel Hill. E-mail to M.S. Wiggers re: Green pitcher plant conservation at North Carolina Botanical Garden. August 20, 2013.

Roe, A., and P. Croll. 2009. Monitoring summary of green pitcher plant (*Sarracenia oreophila*) at Eller Seep. Unpublished report for The Nature Conservancy, NC. 7 pp.

Rogers, W.L., J.M. Cruse-Sanders, R. Determann, and R.L. Malmberg. 2010. Development and characterization of microsatellite markers in *Sarracenia* L. (pitcher plant) species. Conservation Genetics Resources 2:75-79.

Schlauer, J., J. Nerz, and H. Rischer. 2005. Carnivorous plant chemistry. Acta Botanica Gallica 152:187-195.

Schnell, D.E. 1978a. *Sarracenia* L. petal extract chromatography. Castanea 43:107-115.

Schnell, D.E. 1978b. Systematic flower studies of *Sarracenia* L. Castanea 43:211-220.

Schnell, D.E. 1980. Notes on the biology of *Sarracenia oreophila* (Kearney) Wherry. Castanea 45:166-170.

Schnell, D.E. 2002. Carnivorous plants of the United States and Canada, 2nd edn. Timber Press, Portland, OR. 468 pp.

Schnell, D.E., and D.W. Krider. 1976. Cluster analysis of the genus *Sarracenia* L. in the southeastern United States. Castanea 41:165-176.

Shew, M. 2013a. Status of Sarracenia oreophila, green pitcher plant, within Littler River Canyon National Preserve. Unpublished report to U.S. Fish and Wildlife Service, Jackson, MS. 2 pp.

Shew, M. 2013b. Resource Management Specialist, National Park Service, Little River Canyon National Preserve, Alabama. E-mail to M.S. Wiggers re: Green pitcher plant educational activities at Little River Canyon National Preserve. July 19, 2013.

Shew, M. 2013c. Resource Management Specialist, National Park Service, Little River Canyon National Preserve, Alabama. E-mail to M.S. Wiggers re: Green pitcher plant poaching threats. August 16, 2013.

Shew, M. 2013d. Resource Management Specialist, National Park Service, Little River Canyon National Preserve, Alabama. E-mail to M.S. Wiggers re: Comments on green pitcher plant 5-year review draft. October 30, 2013.

Spaulding, L.H., and D.D. Spaulding. 1995. Status survey report on *Sarracenia oreophila* in the Coosa Valley of Alabama. Unpublished report for U.S. Fish and Wildlife Service, Jackson, MS. 3 pp. + appendices.

Stephens, J.D., and D.R. Folkerts. 2012. Life history aspects of *Exyra semicrocea* (pitcher plant moth) (Lepidoptera: Noctuidae). Southeastern Naturalist 11:111-126.

Stein, S.M., M.A. Carr, R.E. McRoberts, L.G. Mahal, and S.J. Comas. 2010. Threats to at-risk species in America's private forests: a Forests on the Edge report. Gen. Tech. Rep. NRS-73. U.S. Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA. 20 pp.

Sutter, R., and N. Rudd. 1997. Monitoring protocols for *Sarracenia oreophila* (Green pitcher plant). Unpublished report for The Nature Conservancy, Southeast Conservation Science Department, Southeast Regional Office, Chapel Hill, NC. 20 pp. + appendices.

Tepedino, V.J. 2012. Overestimating population sizes of rare clonal plants. Conservation Biology 26:945-947.

Thomas, D.D. 2002. Propagation protocol for North American pitcher plants (*Sarracenia* L.). Native Plants Journal 3:50-53.

Thomas, K. 2013a. Park Superintendent, DeSoto State Park, Alabama. E-mail to M.S. Wiggers re: Green pitcher plant educational activities at DeSoto State Park. April 19, 2013.

Thomas, K. 2013b. Park Superintendent, DeSoto State Park, Alabama. E-mail to M.S. Wiggers re: Green pitcher plant management plan at DeSoto State Park. July 29, 2013.

Thomas, K. 2013c. Park Superintendent, DeSoto State Park, Alabama. E-mail to C. Byrd and M.S. Wiggers re: DeSoto State Park green pitcher plant colony status. August 15, 2013.

Troup, R.L., and S. McDaniel. 1980. Current status report on *Sarracenia oreophila*. Unpublished report for the U.S. Fish and Wildlife Service. 62 pp.

U.S. Fish and Wildlife Service (Service). 1994. Green pitcher plant recovery plan. U.S. Fish and Wildlife Service, Jackson, Mississippi. 24 pp.

Walters, C. 2013a. Research Leader, Plant Germplasm Preservation Research, USDA-ARS National Center for Genetic Resources Preservation, Colorado. E-mail to M.S. Wiggers re: Preservation of green pitcher plant seeds at the National Center for Genetic Resources Preservation. August 21, 2013.

Walters, C. 2013b. Research Leader, Plant Germplasm Preservation Research, USDA-ARS National Center for Genetic Resources Preservation, Colorado. E-mail to M.S. Wiggers re: Preservation of green pitcher plant seeds at the National Center for Genetic Resources Preservation. August 21, 2013.

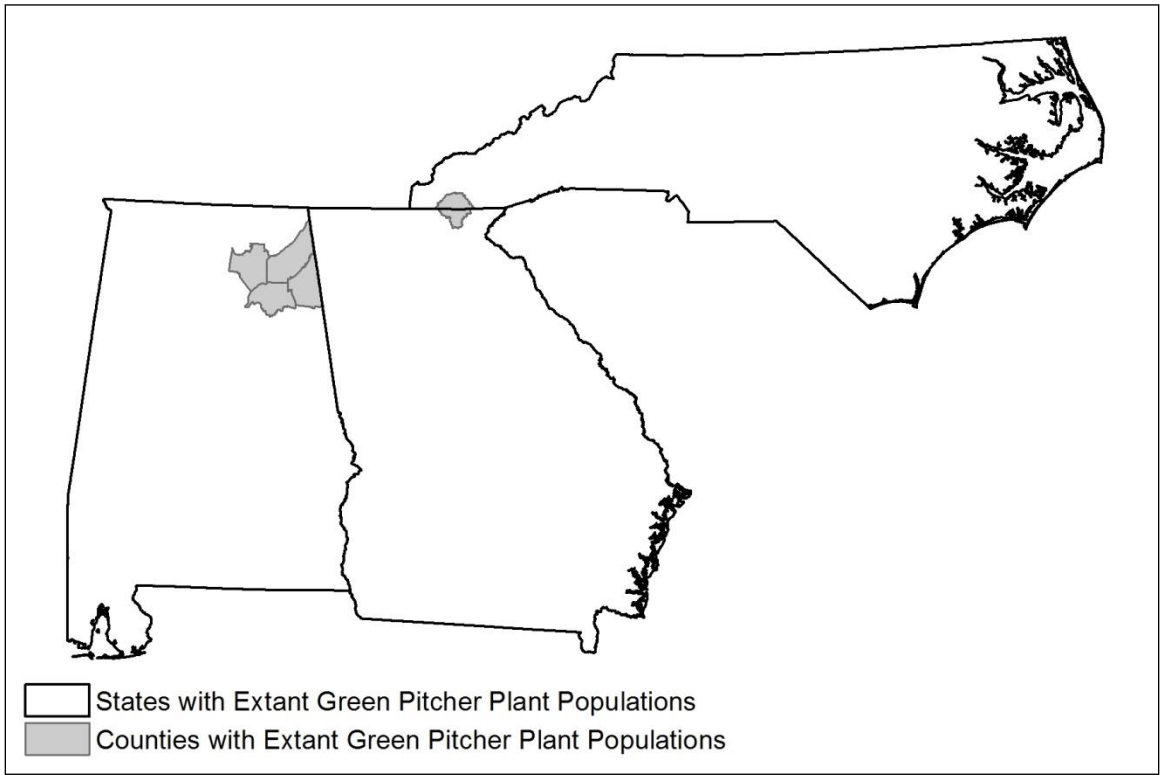
Walther, G.-R. 2010. Community and ecosystem responses to recent climate change. Philosophical Transactions of the Royal Society B 365:2019-2024.

Weakley, A.S., and M.P. Schafale. 1994. Non-alluvial wetlands of the southern Blue Ridge—Diversity in a threatened ecosystem. Water, Air and Soil Pollution 77:359-383.

Wiggers, M.S. 2013. Botanist, U.S. Fish and Wildlife Service. Observations from site visit. June 19, 2013.

Wilcox, J. 2012. Hydrologic controls on the presence and distribution of *Sarracenia oreophila* at Eller Seep. Unpublished report for The Nature Conservancy, North Carolina. 27 pp.

Figure 1. County distribution of extant green pitcher plant populations in Alabama, Georgia, and North Carolina.



U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Green pitcher plant (*Sarracenia oreophila*)

Current Classification: Endangered.

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X__ No change needed

Review Conducted By: M. Scott Wiggers, Mississippi Field Office.

FIELD OFFICE APPROVAL:

for **Lead Field Supervisor, U.S. Fish and Wildlife Service, Mississippi Field Office**

Approve: Cary Norquist Date: 2/25/14

REGIONAL OFFICE APPROVAL:

for
Lead Regional Director, U.S. Fish and Wildlife Service, Southeast Region

Approve: Aaron L Valenti Date: 4-1-14

Appendix A. Summary of peer review for the 5-year review of green pitcher plant (*Sarracenia oreophila*)

A. Peer Review Method: Six peer reviewers were selected by the Service for their knowledge of and expertise with green pitcher plant. Individual responses were received from five of the six peer reviewers.

Peer Reviewers: Mr. Chuck Byrd, The Nature Conservancy, Birmingham, AL; Mr. Ron Determann, Atlanta Botanical Garden, Atlanta, GA; Dr. Debbie Folkerts, Auburn University, Auburn, AL; Dr. Sharon Hermann, Auburn University, Auburn, AL; Mr. Malcolm Hodges, The Nature Conservancy, Atlanta, GA; Ms. Mary Shew, National Park Service, Little River Canyon National Preserve, Fort Payne, AL.

B. Peer Review Charge: See attached guidance.

C. Summary of Peer Review Comments:

1. Summary of Mr. Chuck Byrd's comments.
   a. Agreed with the findings of the 5-year review and did not provide any additional information, editorial comments, or suggested revisions.

2. Summary of Mr. Ron Determann's comments.
   a. Provided a list of suggested conservation actions and observations, including:
      i. Review the inventory of all the sites using current GIS technology and sub meter GPS mapping of individual sites and sub sites.
      ii. Relocate some of the sub sites in Alabama. These sites might hold important outlying genetic entities that might be important for the species' survival.
      iii. Continue to collect seed for long-term cryogenic storage and to use for safeguarding and recovery augmentation.
      iv. More actively work on restoration of the sites by opening them up further to increase light and restore hydrology.
      v. Avoid herbicide use for quick restoration results.
         1) Pitcher deformities have been observed following use of herbicides.
         2) Plants may succumb to fungal attacks and lose vigor.
         3) Herbicides may be transferred through root zones.
         4) Seedlings are particularly sensitive to herbicides.
         5) Herbicides may negatively impact other bog organisms (vegetation, fungi, insects, amphibians, etc.).
         6) Herbicide use should be used only for elimination of invasive exotic plant species.
      vi. Develop a formal network to safeguard genetic material of known provenance to protect against disaster, poaching, or other detrimental occurrences. This has been an effective strategy for restoration of populations other pitcher plant species.
      vii. Incorporate bush hogging and hand mowing to restoration.
      viii. Fire can eliminate seedling recruitment.

ix. Increased use and frequency of early growing season fires can reduce overall biodiversity of green pitcher plant sites.

3. Summary of Dr. Sharon Hermann's comments.
   a. Provided editorial comments and suggested corrections, such as formatting errors and citation omissions.
   b. Provided a brief summary of green pitcher plant's status.
   c. Stated that "an immediate priority for the green pitcher plant must be to restore and maintain high quality habitat on as much public and conservation sites as possible."
   d. Suggested formation of a "working group" to assist with green pitcher plant recovery.
   e. Provided a list of suggested conservation actions:
      i. Compile a review of historical and scientific literature that provides any information [regarding] historical habitat conditions of *Sarracenia oreophila*.
      ii. Emphasize future activities that target:
         1) Public land, but continue to promote value of private property populations.
         2) Upland populations but continue to look for ways to improve techniques for monitoring stream-side clumps; a genetic study may be useful in the future.
         3) Persistence and expansion of patches of pitchers and associated meristems (ramets) based on likelihood that patches represent genets (clones).
         4) Flowering and seed production but not at the expense of assessing and promoting vegetative health (clone sizes, pitcher heights, etc.). *Sarracenia* species are long-lived and as such, on a year-to-year basis, persistence and growth of existing plants is more important than sexual reproduction to population viability.
         5) An improved understanding of fire effects in sites that have been adequately burned in recent years compared to recent burn effects on sites that have experienced fire exclusion. Although *S. oreophila* is assumed to be fire adaptive and its habitat maintained, in part, by relatively frequent burns there are reports that some populations have been harmed by efforts to burn them. It may be that problems created by re-introduction of fire are related, in part, to unnatural types and amount of fuel. The formation of duff, presence of decomposing leaf litter, and/or excessive fuel in general may produce undesired results.
      iii. Evaluate multiple past population monitoring/assessment efforts and determine which methods warrant further consideration and potential inclusion in updated protocols.
      iv. Propose updated protocols:
         1) To be field-tested on a subset of populations that span a range of conditions.
         2) That include GPS mapping.
      v. For at least a portion of the following issues, consider ways to:
         1) Facilitate a range-wide implementation of unified, detailed sampling protocols implemented by the same team.
         2) Promote a goal of once a decade repeating range-wide, unified assessment using a comprehensive approach that might include mapping of patches of pitchers or another method of small-scale quantified assessment.

3) Develop less-detailed but complimentary sampling methods for use by multiple biologists on an annual or biennial basis between more intensive sampling efforts.
4) Assess below-surface factors (especially hydrology and perhaps soil quality) at sites ranging from relatively natural ones to those altered by past road construction and/or hardwood encroachment; this would likely benefit from work that tracked small-scale differences in seepage patterns in areas with and without hardwood encroachment that may be related to past fire exclusion.
5) Assess negative and positive aspects of habitat structure that includes canopy cover, midstory cover, ground layer woody stem cover, and herbaceous cover.
6) Assess large native bees (likely pollinators of *Sarracenia*) as an additional way to monitor ecological health of sites. Sites with a relatively closed canopy, shrubby midstory, and sparse and/or species-poor herbaceous ground layer are less likely to support large native bees compared to more open sites.
7) Compare arthropod prey captured and available for populations in good quality habitat compared to populations in shade and/or otherwise degraded habitat. If feasible, inquilines could be assessed based on habitat quality and other factors.
8) Compare and contrast habitat requirements of related species such as the Mountain sweet pitcher plant, Alabama canebrake pitcher plant, and perhaps more common species. Degrade[d] sites of these species may be more easily accessible for trial habitat restoration efforts that would be similar to those applicable for the Green Pitcher Plant.

vi. Convene a workshop similar to those convened recently for listed vertebrate species such as the gopher tortoise. Activities could include:
1) Learning about observations and concerns of land managers and agency biologists.
2) Sharing results of range-wide assessments.
3) Discussing and evaluating outcomes of assessments.
4) Beta-test implementation of standardized sampling protocols.

4. Summary of Mr. Malcolm Hodges's comments.
   a. Provided positive remarks and agreed with the information summarized for Georgia.
   b. Noted that both Lake Chatuge colonies on protected lands in Georgia and North Carolina may be threatened by increased development upslope of these sites, which could alter hydrological regimes and increase pollution.

5. Summary of Ms. Mary Shew's comments.
   a. Provided positive remarks and agreed with the review's conclusions.
   b. Noted that while green pitcher plant monitoring data at Little River Canyon National Preserve is infrequent, it does indicate that post-burn response of the plants is generally favorable.
   c. Noted difficulties managing the plant with fire on the Preserve, including maintaining regular fire frequency and inability to use growing season fires.
   d. Noted that she and associated personnel are working diligently to support the Preserve's management efforts.

D. Response to Peer Review:

1. Response to Mr. Chuck Byrd.
   a. No response required.

2. Response to Mr. Ron Determann.
   a. Mr. Determann's comments and observations have been addressed as follows:
      i-ii. Included recommendations to update population inventories, map populations, and relocate populations in the Recommendations for Future Actions section (IV).
      iii. Added long-term cryopreservation of seeds as an example of recommended safeguarding efforts in Recommendations for Future Actions section.
      iv. Mr. Determann's suggestion to "more actively work on restoration" is addressed in the first four bullets under section IV.
      v. Mr. Determann's cautions regarding the use of herbicides are addressed in section IV by recommending limited use and study of herbicides as a management tool.
      vi. We have recommended the expansion of preserved genetic stock (i.e., safeguarding) in section IV.
      vii. We have recommended the use, study, and evaluation of alternative management techniques in lieu of fire, including mowing and hand clearing, in section IV.
      viii-ix. Noted fire's potential to eliminate recruitment in the discussion of threat Factor E (other natural or manmade factors affecting its continued existence); cited as Determann 2013c, *in litt.* Also included a recommendation to study and evaluate prescribed fire regimes in section IV.

3. Response to Dr. Sharon Hermann.
   a. Formatting errors and citation omissions were corrected per Dr. Hermann's suggestions.
   b. Many of Dr. Hermann's comments are conservation recommendations that are most appropriate for consideration and inclusion in a future revision of the green pitcher plant's recovery plan (e.g., updating monitoring protocols; habitat comparisons between *S. oreophila* and related species). As such, these suggestions are not addressed herein. However, several of Dr. Hermann's comments and observations warranted additional consideration for this review, including:
      i. We believe that this 5-year review and the recovery plan addresses Dr. Hermann's suggestion to "compile a review of historical and scientific literature" for this species. Additionally, any revision of the species' recovery plan will include an updated review of such historical and scientific literature.
      ii. Noted Dr. Hermann's assertions regarding unnatural fuel accumulations and potentially detrimental fires (comment 3.a.ii.5)) in the discussion of threat Factor E (other natural or manmade factors affecting its continued existence); cited as Hermann 2014, *in litt.*

4. Response to Mr. Malcolm Hodges.
   a. No response required.

b. Mr. Hodges concerns were included in the discussion of threat Factor E (other natural or manmade factors affecting its continued existence); cited as Hodges 2013d, *in litt*.

5. Response to Ms. Mary Shew.
   a. No response required.
   b-d. Included these observations in the summary of Little River Canyon National Preserve's green pitcher plant populations; cited as Shew 2013d, *in litt*.

Guidance for Peer Reviewers of Five-Year Status Reviews
U.S. Fish and Wildlife Service, Mississippi Field Office

As a peer reviewer, you are asked to adhere to the following guidance to ensure your review complies with U.S. Fish and Wildlife Service (Service) policy.

Peer reviewers should:

1. Review all materials provided by the Service.

2. Identify, review, and provide other relevant data apparently not used by the Service.

3. Not provide recommendations on the Endangered Species Act classification (e.g., endangered, threatened) of the species.

4. Provide written comments on:
   - Validity of any models, data, or analyses used or relied on in the review.
   - Adequacy of the data (e.g., are the data sufficient to support the biological conclusions reached). If data are inadequate, identify additional data or studies that are needed to adequately justify biological conclusions.
   - Oversights, omissions, and inconsistencies.
   - Reasonableness of judgments made from the scientific evidence.
   - Scientific uncertainties by ensuring that they are clearly identified and characterized, and that potential implications of uncertainties for the technical conclusions drawn are clear.
   - Strengths and limitations of the overall product.

5. Keep in mind the requirement that the Service must use the best available scientific data in determining the species' status. This does not mean the Service must have statistically significant data on population trends or data from all known populations.

All peer reviews and comments will be public documents and portions may be incorporated verbatim into the Service's final decision document with appropriate credit given to the author of the review.

Questions regarding this guidance or the peer review process should be referred to M. Scott Wiggers, Botanist, Mississippi Ecological Services Field Office, at (601) 364-6910, e-mail: marion_wiggers@fws.gov.